CLAIMS

We claim:

1. An isotopic gas analyzer comprising:

an optical absorption analyzer for analyzing at least one isotope in a sample gas, said optical absorption analyzer including at least one wavelength-stable source of radiation which is specific to said at least one isotope.

2. An isotopic gas analyzer according to claim 1 and wherein said wavelength-stable source is a gas discharge source.

3. An isotopic gas analyzer according to either of the previous claims, and wherein said analyzer determines the ratio of at least two isotopes in said sample gas.

4. An isotopic gas analyzer according to any of the previous claims, and wherein said at least one wavelength-stable source of radiation comprises at least two wavelength-stable sources of radiation, each being specific to at least one isotope.

5. An isotopic gas analyzer according to any of the previous claims, and wherein said at least one wavelength-stable source of radiation which is specific to at least one isotope is specific to two isotopes.

6. An isotopic gas analyzer comprising:

an optical absorption analyzer for analyzing the ratio of at least two isotopes in a sample gas, said optical absorption analyzer including at least one wavelength-stable source of radiation which is specific to said at least one isotope.

7. An isotopic gas analyzer comprising:

an optical absorption analyzer for analyzing at least one isotope in a sample gas, said optical absorption analyzer including two wavelength-stable sources of radiation, each of which is specific to at least one isotope.

8. An isotopic gas analyzer comprising:

an optical absorption analyzer for analyzing at least one isotope in a sample gas, said optical absorption analyzer including at least one wavelength-stable source of radiation which is specific to two isotopes.

9. An isotopic gas analyzer according to claim 1 and wherein said optical absorption analyzer includes a reference gas channel, and wherein at least one of the environmental conditions of said sample gasand said reference gas are the same.

10. An isotopic gas analyzer according to any of the above claims and wherein said reference channel gas is a sample of said sample gas.

11. An isotopic gas analyzer according to claim 9 and wherein said reference channel gas is a mixture containing said at least one isotope at a known pressure and concentration.

12. An isotopic gas analyzer according to claim 9 and wherein the spectral overlap area is utilized by lowering the gas pressures.

13. An isotopic gas analyzer comprising:

at least first and second gas discharge lamps operated with respective first and second different timing characteristics;

at least one detector viewing outputs of said at least first and second gas discharge lamps in the presence of gas to be analyzed; and

a detection differentiator receiving an output from said at least one detector and distinguishing outputs corresponding to the first and second gas discharge lamps on the basis of said first and second different timing characteristics.

14. An isotopic gas analyzer according to claim 13 and wherein said first and second different timing characteristics are first and second frequencies.

15. An isotopic gas analyzer according to claim 13 and wherein said first and second different timing characteristics are first and second phases.

16. An isotopic gas analyzer according to claim 13 and wherein said at least one detector viewing outputs of said at least first and second gas discharge lamps in the presence of gas to be analyzed is a single detector.

17. An isotopic gas analyzer according to claim 13 and wherein said at least one detector viewing outputs of said at least first and second gas discharge lamps in the presence of gas to be analyzed are two detectors, each viewing one of first and second gas discharge lamps.

18. An isotopic gas analyzer according to claim 13 and wherein said at least one detector viewing outputs of said at least first and second gas discharge lamps in the presence of gas to be analyzed are two detectors, one viewing absorption signal outputs from first and second gas discharge lamps and one viewing zero calibration from first and second gas discharge lamps.

19. An isotopic gas analyzer according to claim 13 and wherein said detection differentiator receiving an output from said at least one detector and distinguishing outputs corresponding to the first and second gas discharge lamps on the basis of said first and second different timing characteristics comprises first and second synchronized signal processors.

20. An isotopic gas analyzer comprising:

a discharge lamp containing at least first and second isotope labeled excitation gases;

at least one detector viewing an output of said discharge lamp in the presence of gas to be analyzed;

at least first and second filters corresponding to parts of respective first and second spectra of said at least first and second isotope labeled excitation gases; and

a detection differentiator cooperating with the detector for distinguishing detector outputs corresponding to said at least first and second spectra.

21. An isotopic gas analyzer according to any of the previous claims, and wherein the detection differentiator comprises at least one light valve modulating at least one of said light outputs of said first and second filters in accordance with a known timing sequence.

22. An isotopic gas analyzer according to claim 21 and wherein said at least one light valve modulating at least one of said light outputs of said at least first and second filters in accordance with a known timing sequence is a chopper.

23. An isotopic gas analyzer according to claim 21 and wherein said at least one light valve modulating at least one of said light outputs of said at least first and second filters in accordance with a known timing sequence is a spatial light modulator.

24. An isotopic gas analyzer according to claim 21 and wherein the at least one light valve is operated with respective first and second different timing characteristics and wherein the detection differentiator also comprises a detector output discriminator receiving an output from said detector and distinguishing outputs corresponding to the first and second excitation gases on the basis of said first and second different timing characteristics.

25. An isotopic gas analyzer according to claim 24 and wherein said first and second different timing characteristics are first and second frequencies.

26. An isotopic gas analyzer according to claim 24 and wherein said first and second different timing characteristics are first and second phases.

27. An isotopic gas analyzer according to claim 24 and wherein said detection differentiator comprises first and second synchronized signal processors.

28. An isotopic gas analyzer comprising:

a discharge lamp containing first and second isotope labeled excitation gases;

first and second detectors each viewing an output of said discharge lamp in the presence of gas to be analyzed; and

first and second filters, each corresponding to a part of respective first and second spectra of said first and second isotope labeled excitation gases interposed between said discharge lamp and respective ones of said first and second detectors.

29. An isotopic gas analyzer according to any of the previous claims 20 to 28, and wherein said filters are at least one of optical and gaseous filters.

30. An isotopic gas analyzer comprising:

at least one gas discharge lamp containing at least first and second isotope labeled excitation gases having overlapping spectral ranges including at least some interdigitated spectral lines;

a detector viewing outputs of said at least one gas discharge lamp in the presence of gas to be analyzed; and

a gas contents indicator receiving an output from said detector and employing information detected by said detector from at least two of said at least some interdigitated spectral lines.

31. An isotopic gas analyzer according to claim 30 and wherein said gas to be analyzed is maintained at a pressure below atmospheric pressure

32. An isotopic gas analyzer according to claim 30 and wherein filters are used to isolate non overlapping spectral ranges including at least some interdigitated spectral lines;

33. An isotopic gas analyzer comprising:

an optical absorption analyzer for analyzing at least one isotope in a sample gas, said optical absorption analyzer including at least one wavelength-stable source of radiation which is specific to said at least one isotope;

a channel containing a reference gas; and

osmotic means for achieving substantially the same main isotope concentration in said sample gas and said reference gas.

34. An isotopic gas analyzer comprising:

an optical absorption analyzer for analyzing at least one isotope in a sample gas, said optical absorption analyzer including at least one wavelength-stable source of radiation which is specific to said at least one isotope;

a channel containing a reference gas; and

pumping means for achieving substantially the same main isotope concentration in said sample gas and said reference gas.

35. An isotopic gas analyzer according to any of the previous claims and wherein the gas analyzed is exhaled breath.

36. An isotopic gas analyzer according to claim 35 and wherein only a selected part of said exhaled breath is used for said analyzing.

37. An isotopic gas analyzer according to claim 35 and. wherein an intermediate chamber is used to collect a plurality of breaths from at least part of said exhaled breath, and pumping means used for passing into analyzer.

38. An isotopic gas analyzer according to claim 37 and wherein said intermediate chamber has means to reduce its volume to drive out contents while maintaining substantially constant pressure.

39 An isotopic gas analyzer according to claim 35 and. wherein said exhaled breath. is continuously sampled by means of a connecting nasal cannula.

40. An isotopic gas analyzer according to claim 35 and. wherein said exhaled breath. is continuously sampled by means of a breathing tube.

41. An isotopic gas analyzer according to any of claims 21 to 27 and wherein said light modulation is also performed in at least one of said reference, sample and zero reference channels.

42. An isotopic gas analyzer comprising

an optical absorption analyzer for analyzing at least one isotope in a sample gas, said optical absorption analyzer including at least one wavelength-stable source of radiation which is specific to said at least one isotope;

a channel containing a reference gas; and

mechanical means for changing the length of at least one of the channel lengths, for achieving substantially the same main isotope absorption in said sample gas and said reference gas.

43. An isotopic gas analyzer incorporating a beam homogenizer to compensate for inhomogeneity in the optical path.

44. An isotopic gas analyzer according to any of the previous claims and wherein the spectral ranges of the isotopes of interest are non-overlapping.

45. An isotopic gas analyzer comprising an array of detectors monitoring at least one of said reference, sample and zero reference channels.

46. An apparatus to dynamically collect selected parts of a gas sample.

47. An apparatus acording to claim 46 and wherein said gas sample comprises multiple samples.

48. An apparatus acording to either of claims 46 and 47 and wherein said gas sample is at least one breath of a subject.

49. An apparatus acording to claim 48 and wherein said selected parts of said breath have clinical importance.

50. An isotopic gas analyzer comprising an apparatus to dynamically collect selected parts of a gas sample

51. An isotopic gas analyzer comprising an apparatus according to any of claims 47 to 49.

52. An isotopic gas analyzer according to either of claims 50 and 51, and wherein said gas analyzer is a mass spectrometer.

53. An isotopic gas analyzer according to either of claims 50 and 51, and wherein said gas analyzer is a non-dispersive infra-red spectrometer.

54. An isotopic gas analyzer according to claim 53 and wherein said non-dispersive infra-red spectrometer comprises at least one wavelength stable source of radiation which is specific to said at least one isotope.

55. An isotopic gas analyzer according to any of claims 50 to 54, and wherein at least two samples are collected with the same isotopic ratio of the isotope of interest.

56. An apparatus acording to any of claims 46 to 49, operative as an intermediate chamber system to accumulate gas samples for analysis.

57. An intermediate chamber system, for accumulating at least one gas sample for analysis, comprising :

a breath sensor;

valving means for selecting at least one part of said at least one gas sample; and

a chamber for accumulating said at least one part of said at least one gas sample.

58. An intermediate chamber system according to claim 57 and wherein said breath sensor is a capnographic probe.

59. An intermediate chamber system according to claim 57 and wherein said breath sensor is an optical probe.

60. An intermediate chamber system according to claim 57 and wherein said breath sensor is a pressure probe.

61. An intermediate chamber system according to claim 57 and wherein said breath sensor is a flow probe.

62. An intermediate chamber system according to claim 57 and wherein said valving means comprises at least one check valve.

63. An intermediate chamber system according to claim 57 and wherein said valving means comprises at least one electrically actuated solenoid valve.

64. An intermediate chamber system according to claim 57 and wherein said chamber for accumulating said at least one part of said at least one gas sample is rigid.

65. An intermediate chamber system according to claim 57 and wherein said chamber for accumulating said at least one part of said at least one gas sample is flexible.

66. An intermediate chamber system according to claim 57 and wherein said chamber for accumulating said at least one part of said at least one gas sample is partly rigid and partly flexible.

67. An intermediate chamber system according to any of claims 57 to 66, and wherein at least one part of the system is disposable.

68. An intermediate chamber system according to any of claims 57 to 67, and also comprising dilution means for reducing the concentration of the isotopes of interest.

69. An intermediate chamber system according to claim 68, and wherein said dilution means comprises a switchable gas scrubber.

70. An intermediate chamber system according to any of claims 57 to 69, and wherein the timing of said valving means is determined by the analysis required.

71. An intermediate chamber system according to claim 70, and wherein the timing of said valving means is determined by the results of said analysis.

72. An intermediate chamber system according to either of claims 70 and 71 and wherein the breath collection does not require the intervention of the subject.

73. An intermediate chamber system according to either of claims 70 and 71 and wherein the breath collection does not require operator intervention.

74. An intermediate chamber system according to any of the previous claims and operative to collect a sample of gas for use as the reference gas in the gas analyzer.

75. An intermediate chamber system according to claim 74 and wherein the sample gas is collected from at least the first breath.

76. An intermediate chamber system according to claim 57 and wherein the at least one part of the at least one gas sample accumulated in the chamber is transferred to a gas analyzer.

77. An intermediate chamber system according to claim 76 and wherein the at least one part of the at least one gas sample accumulated in the chamber is transferred to a gas analyzer by means of a collection container.

78. A gas analyzer consisting of an intermediate chamber and wherein the breath sensor is self-calibrated by the gas analyzer.

79. A gas analyzer consisting of an intermediate chamber, and which can be self-calibrated by generating by means of the intermediate chamber a group of diluted samples with the same isotopic ratio, from a single sample of a subject, and comparing

the isotopic ratios measured by the gas analyzer with the fixed isotopic ratio of the samples, and using the results of this comparison to recalibrate the gas analyzer

80. A gas analyzer according to claim 79, and wherein the samples are breath samples.

81. A gas analyzer which is self-calibrated by correlating the spread in the measured isotopic ratio of samples from negative patients, with the spread in the concentration of at least one of the isotopes in the same samples.

82. An intermediate chamber system for collecting a multiplicity of breaths.

83. A gas analyzer comprising an intermediate chamber operative to accumulate samples of gas to be analyzed, and wherein the end concentration of the accumulated samples is determined by the analyzer.

84. An intermediate chamber system according to claim 57 and capable of achieving a predetermined concentration and volume even with temporally changing breaths.

85. An intermediate chamber system according to claim 57 and capable of collecting breaths from the plateau region of the carbon dioxide wavefront of a subject.

86. An intermediate chamber system comprising a computer controlled gas handling system consisting of:

a gas sensor;
a first solenoid valve;
a second solenoid valve;
a gas scrubber;
a pump;
at least one collection container; and
at least a third solenoid valve;

the first solenoid valve directing gas into one of two paths, one of which discards the gas, and the other of which passes it either through the gas scrubber to the second solenoid valve, or directly to the second solenoid valve, the pump pumping gas from

the second solenoid valve into the at least one collection container, the third solenoid valve being operative to pass gas in the at least one collection container for analysis.

87. A method for accumulating at least one sample of gas to be analyzed, wherein the end concentration of the accumulated samples is determined by the analyzer, and consisting of the steps of:

measuring the gas concentration;

deciding whether to accumulate said at least one sample;

calculating the content of the accumulated gas; and

deciding whether to continue collecting further samples according to the whether the accumulated gas has reached a desired concentration and volume.

88. A method for accumulating at least one sample of gas to be analyzed, wherein the end concentration of the accumulated samples is determined by the analyzer, according to claim 87, and wherein and said at least one sample of gas to be analyzed is at least one breath sample.

89. An intermediate chamber system according to any ofclaims 57 to 86, and wherein the at least one gas sample for analysis is collected by means of a nasal cannula.

90. An intermediate chamber system according to any of claims 57 to 86, and wherein the at least one gas sample for analysis is collected by means of an oral breath tube.

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